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(54) **OIL-IMMERSED SOLENOID**

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USPC 335/260
See application file for complete search history.

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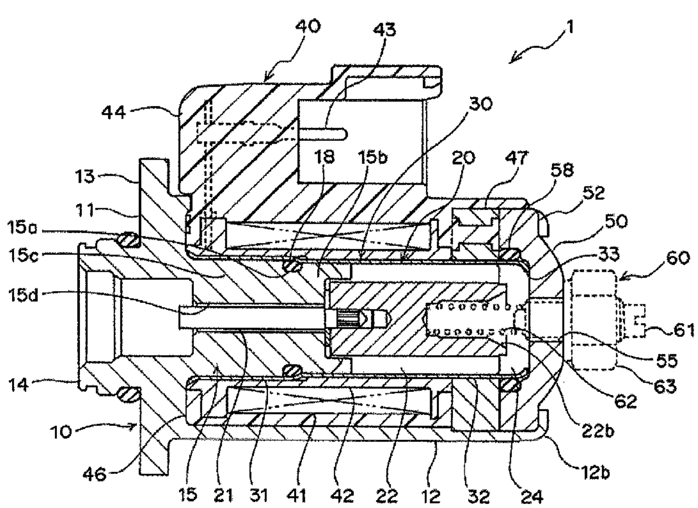
(57) **ABSTRACT**

An oil-immersed solenoid is provided with a casing including a base, a cylinder, and a flange in an integral manner, a fixed magnetic pole, a plunger having an armature, a guide pipe, a coil unit including a bobbin around which a coil is wound, and a cover, the fixed magnetic pole is integrated with the casing, and in the state where the plunger, the guide pipe, the coil unit, and the cover are attached in the cylinder of the casing, a front end of the cylinder is swaged, thereby holding the plunger, the guide pipe, the coil unit, and the cover in the casing.

6 Claims, 15 Drawing Sheets



(51) **Int. Cl.**
H01F 7/127 (2006.01)
H01F 7/16 (2006.01)

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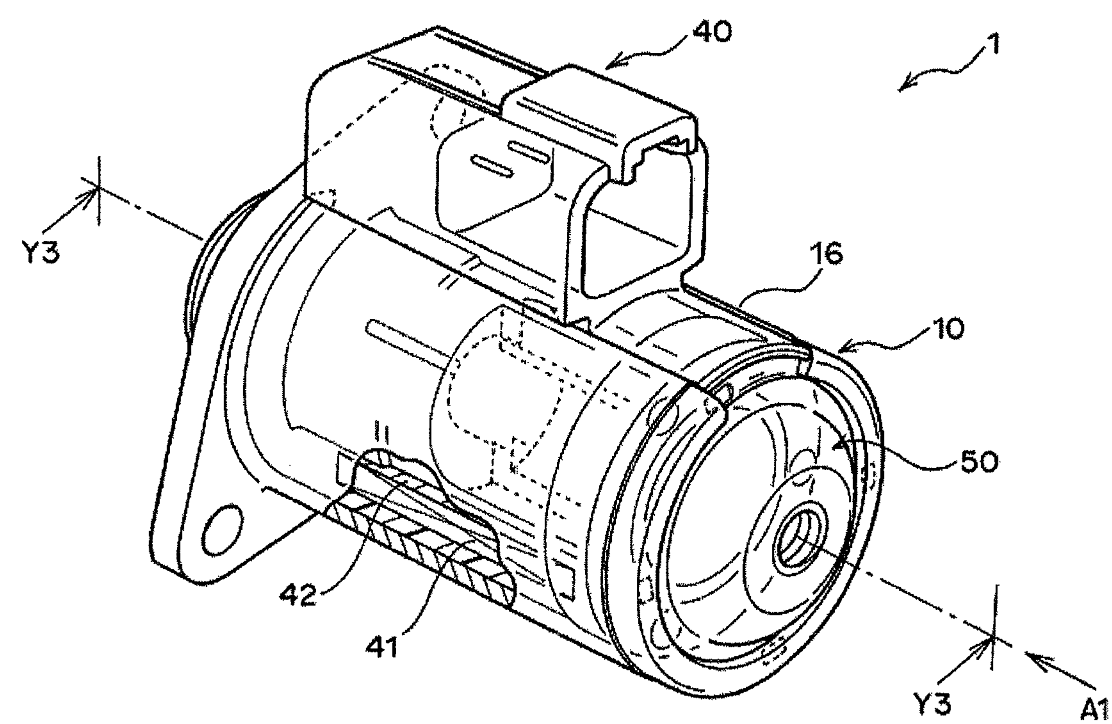
Fig.1



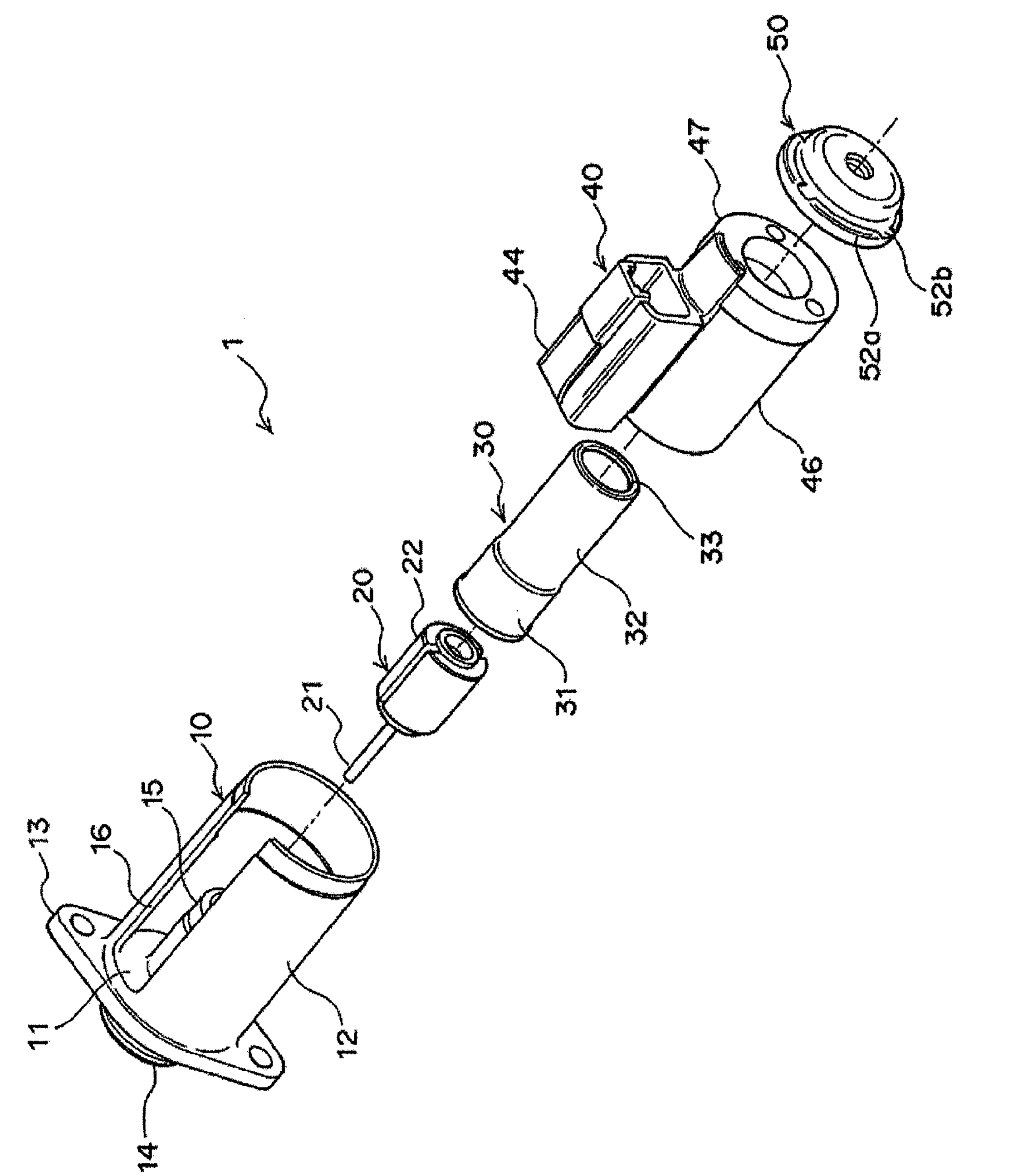


Fig.2

Fig.3

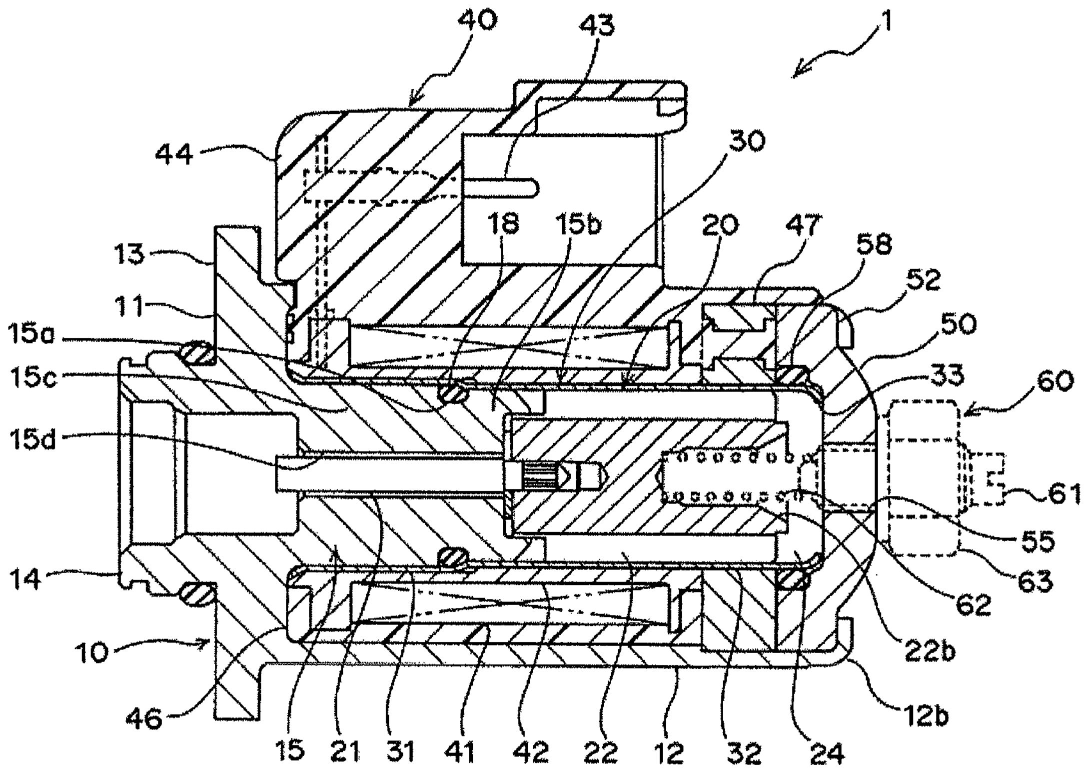

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Fig.4

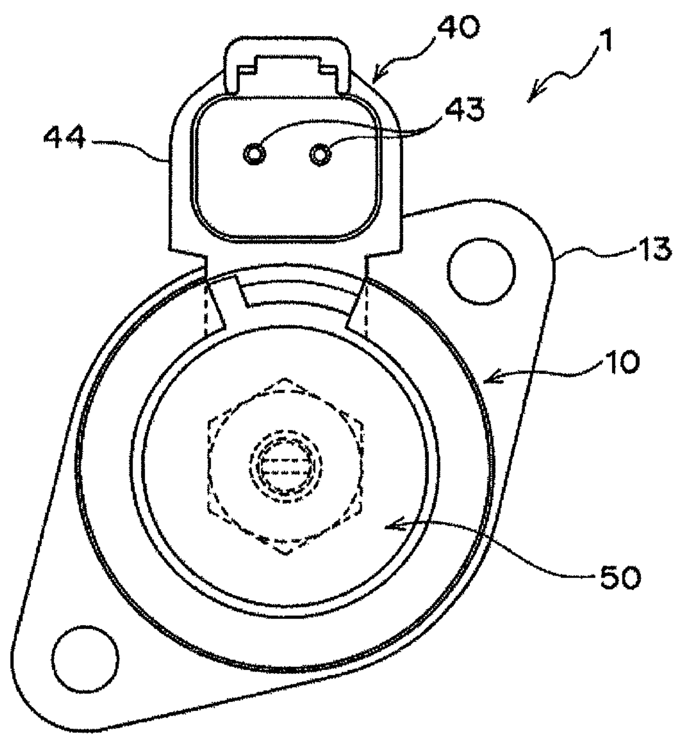


Fig.5

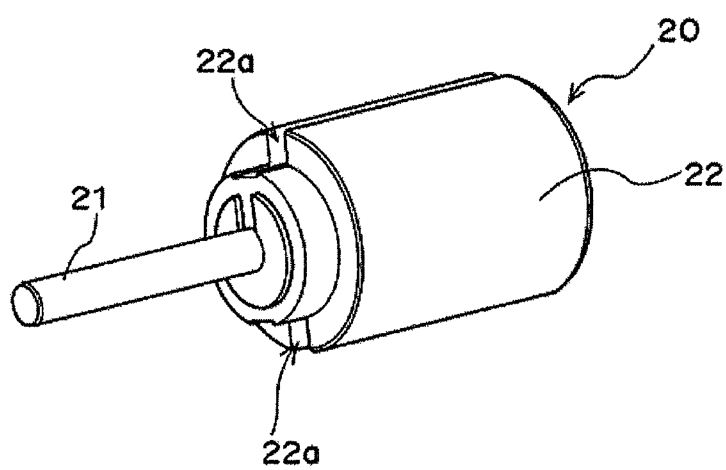


Fig.6

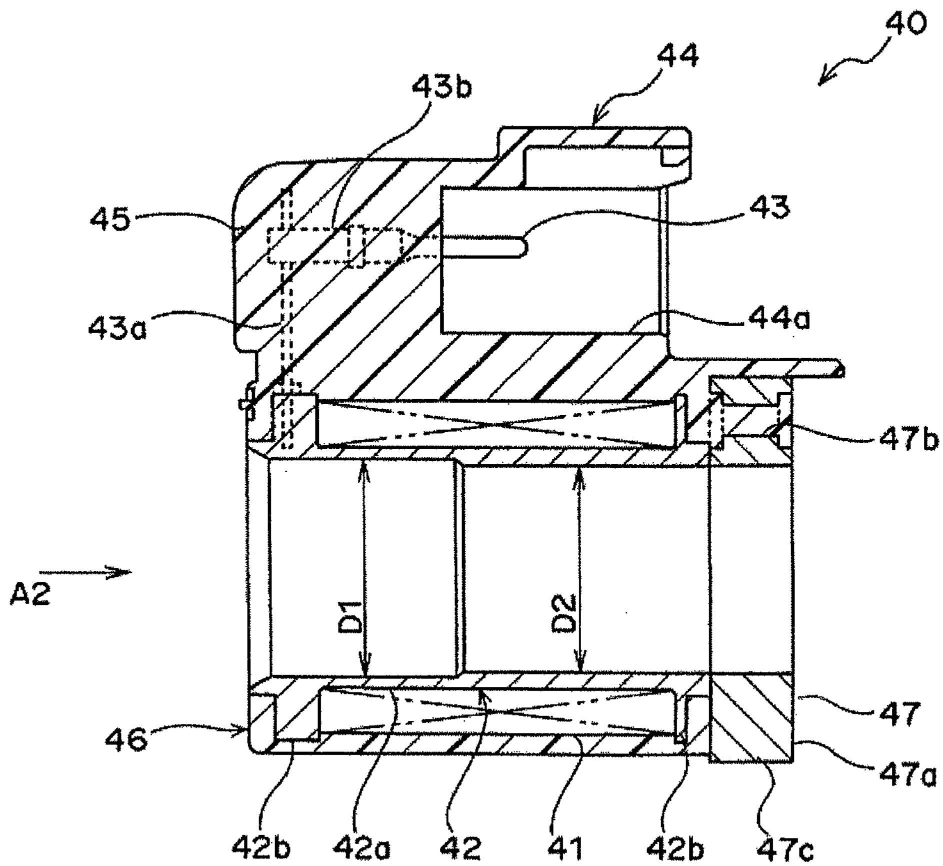


Fig.7

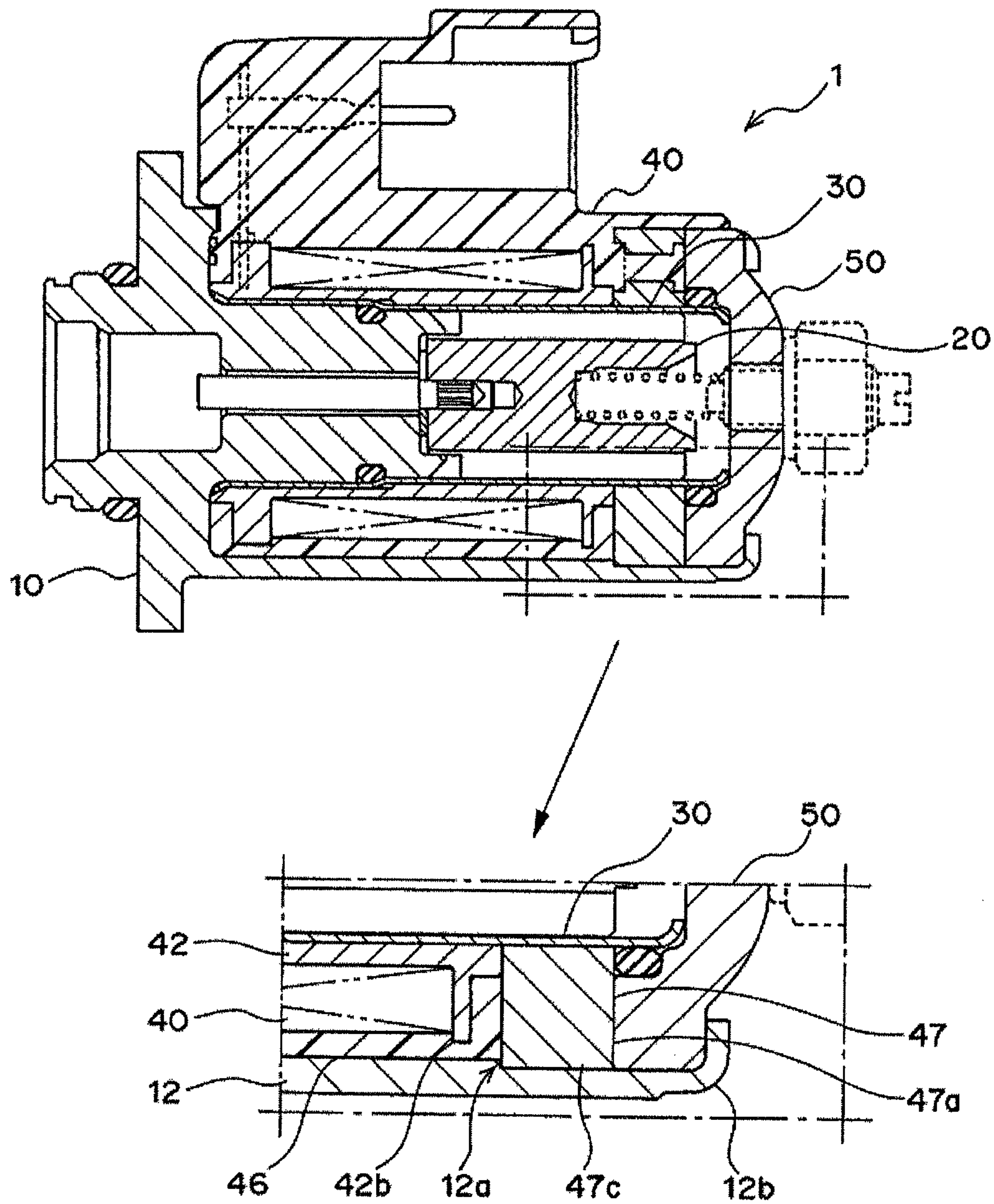


Fig.8

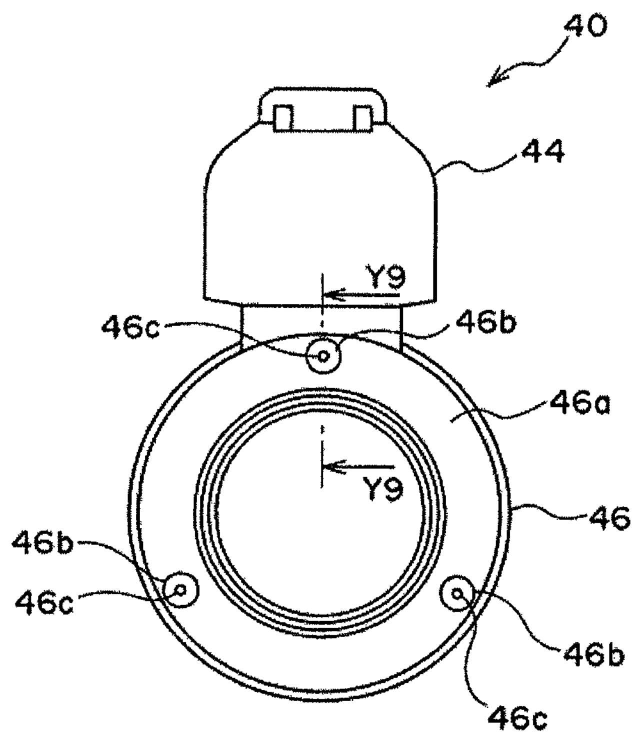


Fig.9

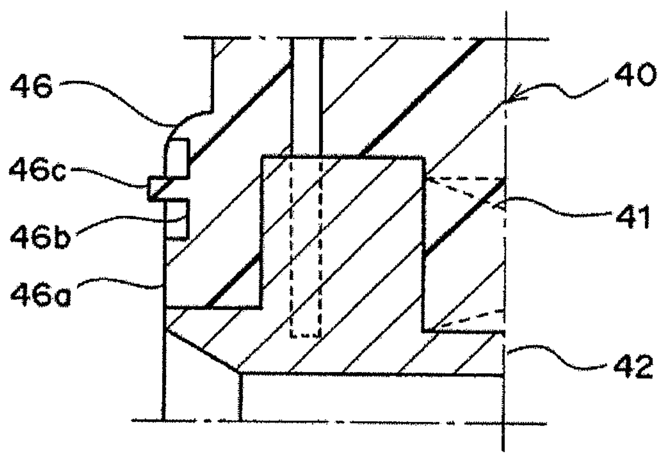


Fig.10

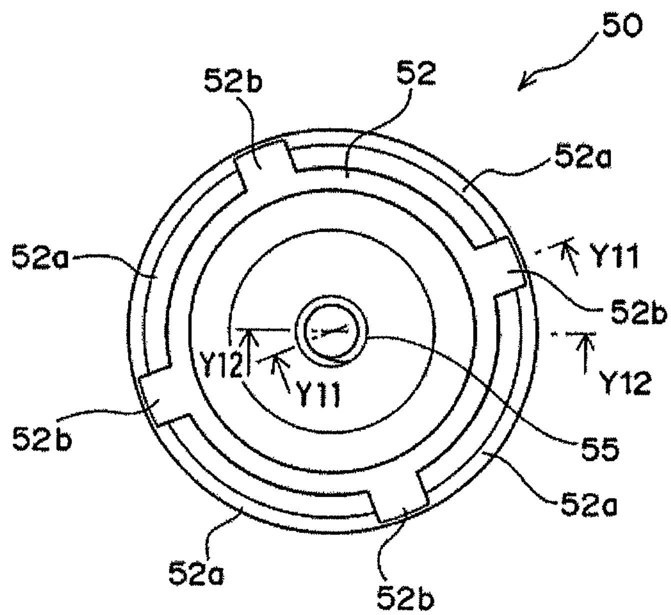


Fig.11

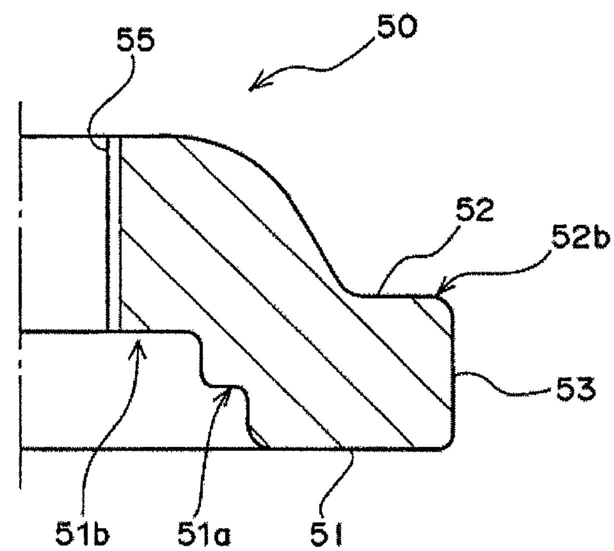


Fig.12

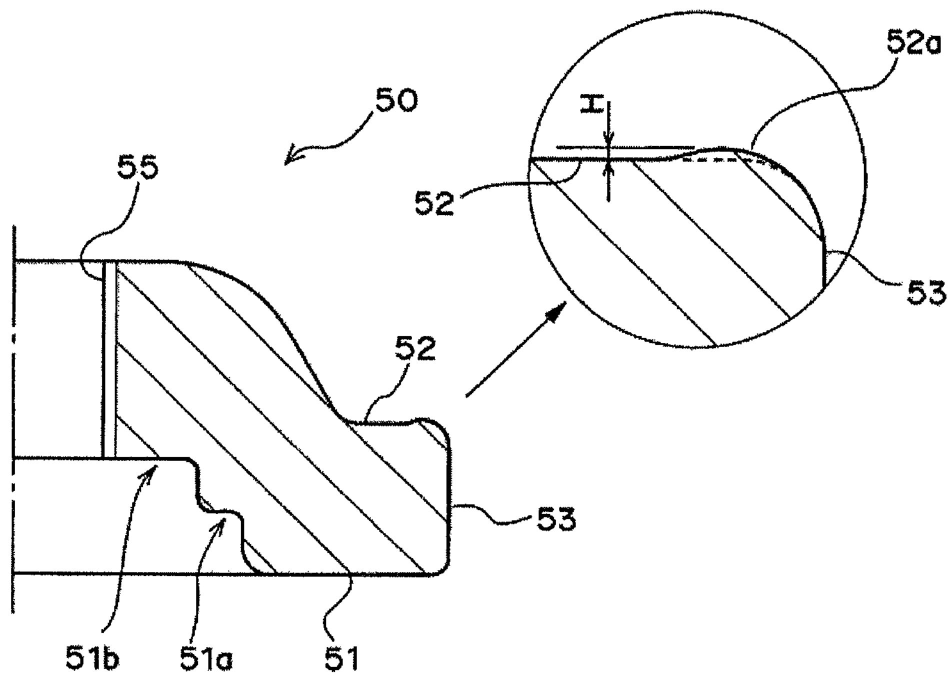
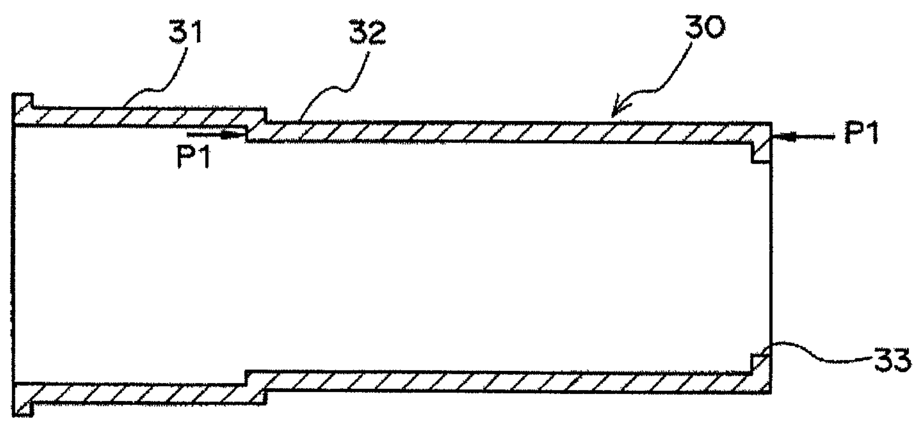


Fig.13



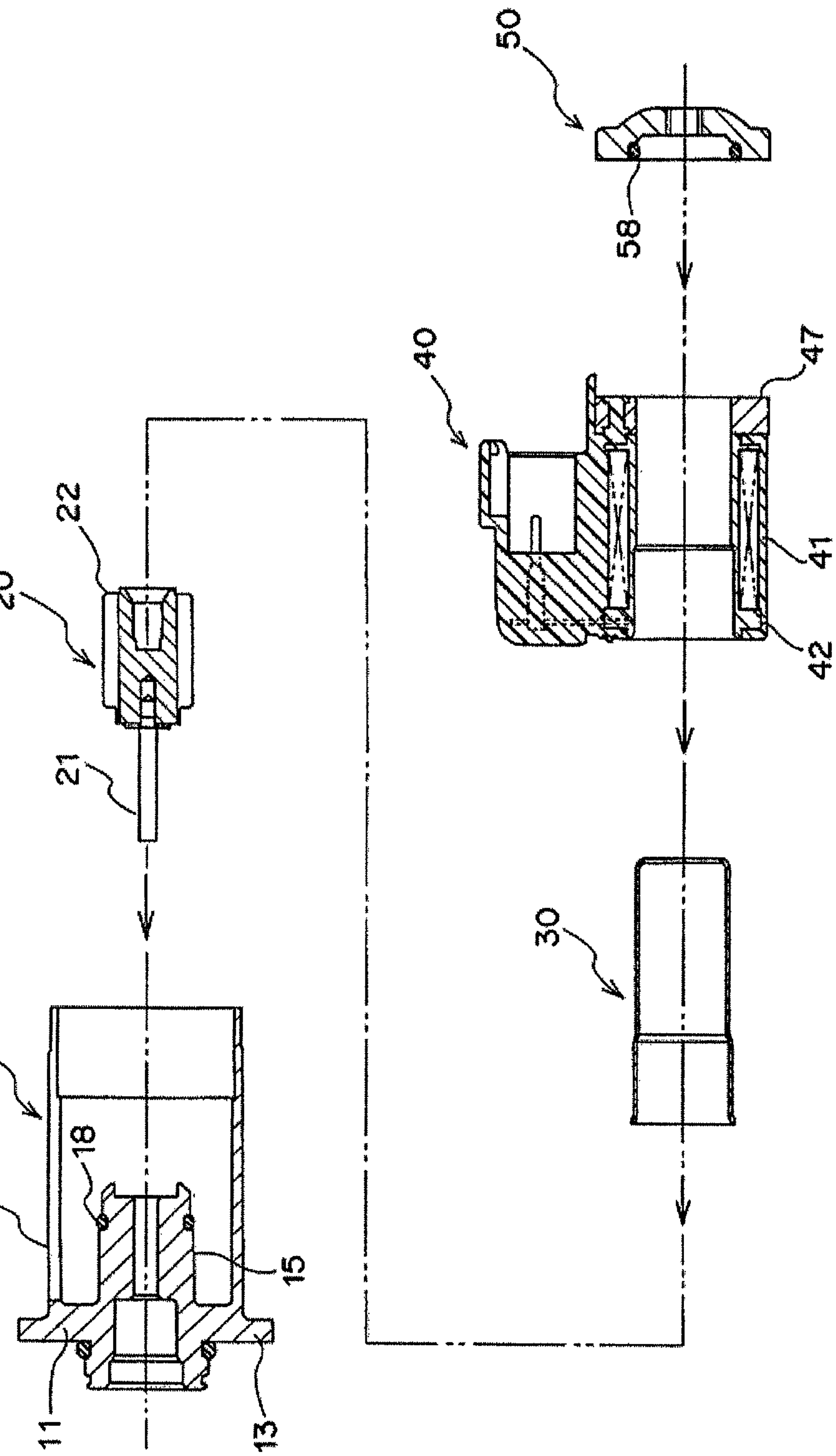
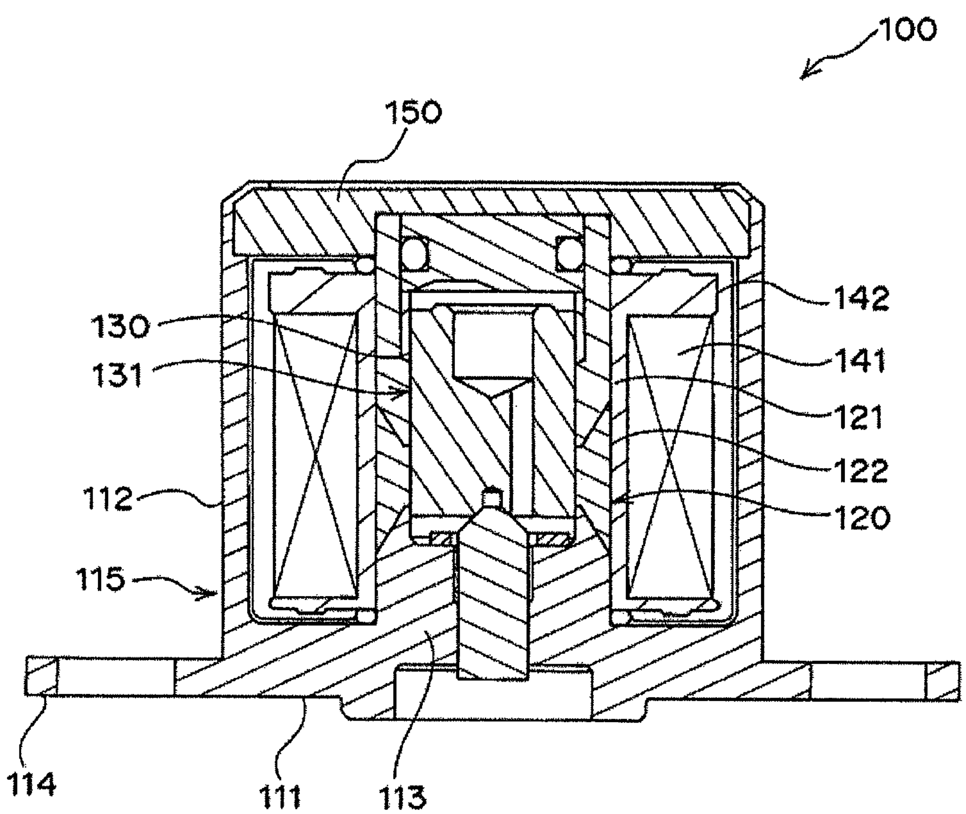


Fig. 14

Fig. 15



OIL-IMMERSED SOLENOID

TECHNICAL FIELD

The present invention relates to an oil-immersed solenoid used in a valve device for controlling hydraulic equipment for construction machinery and industrial machinery.

BACKGROUND OF THE INVENTION

As well known, oil-immersed solenoids are widely used in valve devices for controlling hydraulic equipment for construction machinery and industrial machinery. A generally-known oil-immersed solenoid includes a coil, a fixed magnetic pole, and an armature, and energizes the coil in the state where hydraulic oil is filled in a space that houses the armature, thereby causing the fixed magnetic pole to suck the armature so as to move a shaft fixed to the armature.

For example, Patent Document 1 discloses such an oil-immersed solenoid. As shown in FIG. **15**, the solenoid **100** includes a casing **115** forged by integrating a base **111**, an outer cylinder **112**, a lower fixed magnetic pole **113** and a flange **114**, an inner cylinder **120** jointed to the lower fixed magnetic pole **113** of the casing **115**, a plunger **130** having an armature **131** housed in the inner cylinder **120**, a bobbin **142** around which a coil **141** is wound, and a cover **150**, and energizes the coil **141** to move the plunger **130**.

Patent Document 1: JP 2006-300222 A

However, in the solenoid **100** described in Patent Document 1, as shown in FIG. **15**, the inner cylinder **120** is formed by brazing an upper fixed magnetic pole **121** as a magnetic body to a cylinder **122** as a nonmagnetic body, and the inner cylinder **120** is brazed to the lower fixed magnetic pole **113** of the casing **115**.

Then, the plunger **130** is inserted into the inner cylinder **120** jointed to the casing **115**, the bobbin **142** around which the coil **141** is wound is fitted to the outer circumference of the inner cylinder **120**, the cover **150** is placed thereon and then, a front end of the outer cylinder **112** is swaged to the cover **150** to assemble the solenoid **100**.

In the solenoid **100** thus assembled, the inner cylinder **120** is formed by brazing and the inner cylinder **120** is brazed to the lower magnetic pole **113** of the casing **115**. Since multiple times of brazing is required, the number of man-hours needed for assembling is large, disadvantageously increasing assembling costs.

Therefore, an object of the present invention is to provide an oil-immersed solenoid that can be easily assembled, greatly reducing the number of man-hours needed for assembling, and in turn, decreasing assembly costs.

SUMMARY OF THE INVENTION

To attain the object, the present invention is configured as follows.

Firstly, a first aspect of the present invention provides an oil-immersed solenoid used for hydraulic control equipment, the oil-immersed solenoid including: a casing including a base, a cylindrical cylinder extending from the base, and a flange extending from the base to an outside of the cylinder in an integral manner; a fixed magnetic pole disposed to extend from the base into the cylinder; a plunger including a shaft inserted into an insertion hole extending along an axis of the fixed magnetic pole, and an armature to which the shaft is fixed; a cylindrical guide pipe fitted to an outer circumference of the fixed magnetic pole to cover the plunger; a coil unit including a main body around which a coil is wound, and a connector provided on an outer circumferential face of the main body; and a cover disposed in the cylinder to cover the guide pipe and the coil unit from an opposite side to the base of the casing, wherein the fixed magnetic pole is integrated with the casing or the fixed magnetic pole is attached to the casing, the cylinder of the casing has a notch cut in a circumferential direction to correspond to the connector of the coil unit, and the plunger is attached in the cylinder of the casing so as to insert the shaft into the insertion hole of the fixed magnetic pole, the guide pipe is fitted to the outer circumference of the fixed magnetic pole to cover the plunger, the coil unit is inserted into a gap between the cylinder of the casing and the guide pipe, the cover is attached to cover the guide pipe and the coil unit, and in this state, a front end of the cylinder is swaged to the cover, to hold the plunger, the guide pipe, the coil unit, and the cover in the casing.

Moreover, a second aspect of the present invention is directed to the oil-immersed solenoid according to the first aspect, wherein a yoke is integrated with the coil unit, the yoke disposed adjacent to the main body on a side where the cover is arranged, and having an outer circumference of a larger outer diameter than the coil unit, and a step engaged with the outer circumference of the yoke is formed on an inner face of the cylinder of the casing.

Further, a third aspect of the present invention is directed to the oil-immersed solenoid according to the first or second aspect, wherein the coil unit has a recess in its opposed face to the base of the casing, and a projection protruding from the base of the recess further than the opposed face, in the recess.

Furthermore, a fourth aspect of the present invention is directed to the oil-immersed solenoid according to any one of the first to third aspects, wherein the cover has a protrusion protruding from an edge of a face of the cover, the face making contact with the front end of the cylinder when the front end of the cylinder is swaged.

Furthermore, a fifth aspect of the present invention is directed to the oil-immersed solenoid according to any one of the first to fourth aspects, the cover has a groove on an edge of a face of the cover, the face making contact with the front end of the cylinder when the front end of the cylinder is swaged, the groove being axially dented further than a remaining area of the edge.

Furthermore, a sixth aspect of the present invention is directed to the oil-immersed solenoid according to any one of the first to fifth aspects, wherein the guide pipe includes a large-diameter portion fitted to the fixed magnetic pole and a small-diameter portion fitted to the armature of the plunger, and both axial ends of the small-diameter portion are pressed by hydraulic oil.

ADVANTAGE OF THE INVENTION

With such configuration, the present invention can achieve following effects.

According to the first aspect of the present invention, by integrating the fixed magnetic pole with the casing or attaching the fixed magnetic pole to the casing, attaching the plunger in the cylinder of the casing, fitting the guide pipe to the outer circumferences of the fixed magnetic pole and the plunger, fitting the coil unit to the outer circumference of the guide pipe, attaching the cover so as to cover the guide pipe and the coil unit, and swaging the front end of the cylinder to the cover, the plunger, the guide pipe, the coil unit, and the cover are held in the casing. Since the solenoid can be assembled so easily by sequentially inserting the plunger, the guide pipe, the coil unit, and the cover into the casing and then, swaging the front end of the cylinder of the casing, the number of man-hours for assembling can be greatly decreased to reduce assembling costs.

According to the second aspect of the present invention, since the yoke that is disposed adjacent to the main body on the side where the cover is arranged and has the outer circumference of the larger outer diameter than the coil unit is integrated with the coil unit, and the step engaged with the outer circumference of the yoke is formed on the inner face of the cylinder of the casing, in the case where the yoke is disposed in the solenoid as compared to the case where the yoke and the coil unit are separate members, the number of man-hours for assembling can be reduced and further, the yoke and the coil unit can be held at a predetermined position, preventing rattle. Moreover, since only the yoke receives a pressing force at swaging, and the coil unit is not subjected to the pressing force, deformation of the coil unit can be prevented.

According to the third aspect of the present invention, since the coil unit has the recess in the end face opposed to the base of the casing, and the projection protruding from the base of the recess further than the opposed face in the recess, when the front end of the cylinder of the casing is swaged to the cover, the projection of the coil unit is squashed by the base of the casing such that the coil unit is held by the casing, thereby holding the coil unit at the predetermined position to suppress rattle. Further, it is possible to prevent the coil unit from oscillating when an external load acts on the solenoid.

According to the fourth aspect of the present invention, since the cover has, on the edge of the face of the cover against which the front end of the cylinder contacts when the front end of the cylinder is swaged, the protrusion protruding from the face, the front end of the cylinder can be swaged along the protrusion in consideration that the front end of the cylinder is returned by spring back, and the front end of the cylinder can be bent at a predetermined angle with high accuracy.

According to the fifth aspect of the present invention, since the cover has, on the edge of the face of the cover against which the front end of the cylinder contacts when the front end of the cylinder is swaged, the groove axially dented further than the remaining area of the edge, when the front end of the cylinder is swaged to the cover, the front end of the cylinder can be dug into the groove of the cover, preventing rotation of the cover relatively easily without changing an assembling process.

According to the sixth aspect of the present invention, since the guide pipe has the large-diameter portion fitted to the fixed magnetic pole and the small-diameter portion fitted to the armature of the plunger, and both axial ends of the small-diameter portion are pressed by hydraulic oil, a uniform pressing force acts on the both axial ends of the small-diameter portion, preventing the movement of the guide pipe to improve the reliability of the solenoid.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an oil-immersed solenoid in accordance with the embodiment of the present invention.

FIG. **2** is an exploded perspective view of the solenoid shown in FIG. **1**.

FIG. **3** is a sectional view of the solenoid taken along a line **Y3**-**Y3** in FIG. **1**.

FIG. **4** is a front view of the solenoid when viewed from a direction A**1** in FIG. **1**.

FIG. **5** is a perspective view of a plunger of the solenoid.

FIG. **6** is a sectional view of a coil unit of the solenoid.

FIG. **7** is an enlarged view of a main part of the solenoid.

FIG. **8** is a front view of the coil unit when viewed from a direction A**2** in FIG. **6**.

FIG. **9** is a sectional view of the coil unit taken along a line **Y9**-**Y9** in FIG. **8**.

FIG. **10** is a front view of the cover of the solenoid.

FIG. **11** is a sectional view of the cover taken along a line **Y11**-**Y11** in FIG. **10**.

FIG. **12** is a sectional view of the cover taken along a line **Y12**-**Y12** in FIG. **10**.

FIG. **13** is a sectional view schematically showing a guide pipe of the solenoid.

FIG. **14** is a view illustrating a method of assembling the solenoid.

FIG. **15** is a sectional view of a conventional oil-immersed solenoid.

EMBODIMENT OF THE INVENTION

An embodiment of the present invention will be described with reference to appended figures.

FIG. **1** is a perspective view of an oil-immersed solenoid in accordance with the embodiment of the present invention. FIG. **2** is an exploded perspective view of the solenoid shown in FIG. **1**. FIG. **3** is a sectional view of the solenoid taken along a line **Y3**-**Y3** in FIG. **1**. FIG. **4** is a front view of the solenoid when viewed from a direction A**1** in FIG. **1**. FIG. **3** and FIG. **4** show a biasing force adjusting mechanism for adjusting a biasing force of the plunger in a broken line.

As shown in FIG. **1** to FIG. **4**, the oil-immersed solenoid **1** in accordance with the embodiment of the present invention is used in a valve device (hydraulic control equipment) for controlling hydraulic equipment for construction machinery, and includes a casing **10**, a plunger **20**, a guide pipe **30**, a coil unit **40**, and a cover **50**, as main constituents.

The casing **10** has a substantially disc-like base **11**, a substantially cylindrical cylinder **12** extending from the edge of the base **11**, a flange **13** extending from the base **11** to the outside of the cylinder **12**, and an attachment portion **14** extending from the base **11** to the opposite side to the cylinder **12**. In the casing **10** formed by forging a magnetic material such as carbon steel, the base **11**, the cylinder **12**, the flange **13**, and the attachment portion **14** are integrally formed.

A fixed magnetic pole **15**, in which magnetic poles are generated by a coil **41** of the coil unit **40**, is disposed in the cylinder **12** of the casing **10**, and extends from the base **11** in a substantially cylindrical manner. The fixed magnetic pole **15** has an annular groove **15***a* having the outer circumference to which a sealing member **18** is attached, and a front end portion **15***b* closer to the front end than the annular groove **15***a* has a smaller outer diameter than a bottom portion **15***c* closer to the base **11** than the annular groove **15***a*. An axially-extending insertion hole **15***d* is formed at the center of the fixed magnetic pole **15**.

In the present embodiment, the fixed magnetic pole **15** is also made of a magnetic material such as carbon steel, and is integrated with the casing **10** by forging. It is noted that the fixed magnetic pole **15** is not necessarily integrated with the casing **10**, and the fixed magnetic pole **15** may be attached to the casing **10**.

The plunger **20** has an armature **22** to which a shaft **21** to be inserted into the insertion hole **15***d* of the fixed magnetic pole **15** is fixed. The shaft **21** is inserted into the insertion hole **15***d* of the fixed magnetic pole **15**, and its front end is connected to a spool of the valve device not shown.

FIG. **5** is a perspective view of the plunger of the solenoid. As shown in FIG. **5**, the armature **22** of the plunger **20** is substantially cylindrical, and two axially-extending communicating grooves **22***a* are axisymmetrically formed in the side face of the armature **22**. The communicating grooves **22***a* is provided such that, when the armature **22** moves in the state where hydraulic oil is filled in a space **24** that houses the plunger **20**, the hydraulic oil can move through the communicating grooves **22***a*.

In the state where the shaft **21** and the armature **22** are disposed on the same axis in the plunger **20**, the shaft **21** is press-fitted into the armature **22** in an integral manner. The shaft **21** is made of a nonmagnetic material such as stainless steel, and the armature **22** is made of a magnetic material such as carbon steel.

The guide pipe **30** has a substantially cylindrical shape corresponding to the shapes of the fixed magnetic pole **15** and the armature **22**. The guide pipe **30** has a large-diameter portion **31** fitted to the bottom portion **15***c* of the fixed magnetic pole **15**, and a small-diameter portion **32** fitted to the front end portion **15***b* of the fixed magnetic pole **15** and the armature **22** of the plunger **20**. An inner diameter of the large-diameter portion **31** is larger than an inner diameter of the small-diameter portion **32** by the thickness of the guide pipe **30**, and the inner diameter of the large-diameter portion **31** is almost equal to an outer diameter of the small-diameter portion **32**.

The guide pipe **30** is fitted to outer circumferences of the fixed magnetic pole **15** and the plunger **20** such that an end on the side of the large-diameter portion **31** contacts the base **11** of the casing **10**, and when the guide pipe **30** is fitted to outer circumferences of the fixed magnetic pole **15** and the plunger **20**, the guide pipe **30** defines a space **24** in which the armature **22** of the plunger **20** moves axially.

In the present embodiment, the guide pipe **30** is formed by deep-drawing a nonmagnetic material such as stainless steel into a bottomed cylinder and then, making an opening **33** on its bottom by punching. The guide pipe **30** may be a bottomed cylinder without an opening on its bottom.

FIG. **6** is a sectional view of the coil unit of the solenoid. As shown in FIG. **6**, the coil unit **40** includes a bobbin **42** around which the coil **41** is wound, and the bobbin **42** has a substantially cylindrical cylinder **42***a* around which the coil **41** is wound, and flanges **42***b* at both axial ends of the cylinder **42***a* so as to extend outward from the cylinder **42***a*.

In the bobbin **42**, an inner diameter D**1** of the cylinder **42***a* is made larger than the outer diameter of the large-diameter portion **31** of the guide pipe **30**, and an inner diameter D**2** of the cylinder **42***a* is made larger than the outer diameter of the small-diameter portion **32** of the guide pipe **30**. The coil unit **40** is configured by fitting the bobbin **42** to the outer circumference of the guide pipe **30**.

The coil unit **40** further includes a connector **44** with a terminal **43** for supplying current to the coil **41**. The terminal **43** is configured of a first terminal piece **43***a* that is connected to the coil **41** and extends outward from the flange **42***b* of the bobbin **42** and a second terminal piece **43***b* that is connected to the first terminal piece **43***a* and extends along the axis of the bobbin **42**, and a front end of the second terminal piece **43***b* protrudes into a plug connection port **44***a*.

The coil **41**, the first terminal piece **43***a*, and the second terminal piece **43***b* each are made of a conductive material such as copper, and the bobbin **42** is made of a nonmagnetic material such as thermoplastic synthetic resin. The coil unit **40** is insert-molded by using thermoplastic synthetic resin in the state where the first terminal piece **43***a* and the second terminal piece **43***b* are assembled to the bobbin **42** around which the coil **41** is wound, to have a substantially cylindrical main body **46** formed by covering the coil **41** and the bobbin **42** with a mold layer **45**, and the connector **44** formed by covering the terminal **43** with the mold layer **45**.

The outer circumference of the main body **46** is inserted into the cylinder **12** of the casing **10**. The connector **44** protrudes to the outside of the cylinder **12** of the casing **10** through a notch **16** formed by cutting the cylinder **12** of the casing **10** in the circumferential direction so as to correspond to the connector **44**.

A yoke **47** is disposed adjacent to the main body **46** of the coil unit **40** on the side where the cover **50** is arranged. The yoke **47** has a ring-like annular portion **47***a* made of a magnetic material such as carbon steel, and a plurality of through holes **47***b* axially penetrate the annular portion **47***a*. In the present embodiment, the three through holes **47***b* are formed at regular intervals in the circumferential direction.

In the present embodiment, the coil unit **40** is insert-molded in the state where the first terminal piece **43***a* and the second terminal piece **43***b* are assembled to the bobbin **42** around which the coil **41** is wound, and the yoke **47** is disposed adjacent to the bobbin **42**, to form the mold layer **45** in the through holes **47***b* of the yoke **47** and integrate the yoke **47** with the coil unit **40**.

FIG. **7** is an enlarged view of a main part of the solenoid. As shown in FIG. **7**, an inner diameter of the yoke **47** is almost equal to an inner diameter of the adjacent bobbin **42**, an outer diameter of the yoke **47** is larger than an outer diameter of the main body **46** of the coil unit **40**, and the yoke **47** has an outer circumference **47***c* that has a larger outer diameter than the coil unit **40**.

A step **12***a* to be engaged with the outer circumference **47***c* of the yoke **47** is formed on an inner face of the cylinder **12** of the casing **10**, and when the coil unit **40** is assembled to the casing **10**, the outer circumference **47***c* of the yoke **47** integrated with the coil unit **40** contacts the step **12***a* of the cylinder **12**.

By integrating the yoke **47** having the outer circumference **47***c* disposed adjacent to the main body **46** on the side where the cover **50** is arranged, and the coil unit **40** with each other, and forming the step **12***a* to be engaged with the outer circumference **47***c* of the yoke **47** on the inner face of the cylinder **12** of the casing **10**, in the case where the yoke **47** is disposed in the solenoid **1** as compared to the case where the yoke **47** and the coil unit **40** are separate members, the number of man-hours for assembling can be reduced and further, the yoke **47** and the coil unit **40** can be held at a predetermined position, preventing rattle. Moreover, since only the yoke **47** receives a pressing force at swaging, and the coil unit **40** is not subjected to the pressing force, deformation of the coil unit **40** can be prevented.

FIG. **8** is a front view of the coil unit when viewed from a direction A2 in FIG. **6**. FIG. **9** is a sectional view of the coil unit taken along a line Y**9**-Y**9** in FIG. **8**. As shown in FIG. **8** and FIG. **9**, the coil unit **40** has an end face **46***a* on the opposite side to an end face of the main body **46** on which the yoke **47** is disposed, cylindrical recesses **46***b* are opened from the end face **46***a*, and cylindrical projections **46***c* axially extending from bases of the respective recesses **46***b* protrude beyond the end face **46***a* of the main body **46**. The three recesses **46***b* and the three projections **46***c* are formed at regular intervals in the circumferential direction on the end face **46***a* of the main body **46**.

FIG. **10** is a front view of the cover of the solenoid. FIG. **11** is a sectional view of the cover taken along a line Y**11**-Y**11** in FIG. **10**. FIG. **12** is a sectional view of the cover taken along a line Y**12**-Y**12** in FIG. **10**.

As shown in FIG. **10** to FIG. **12**, the cover **50** is made of a nonmagnetic material such as stainless steel or a magnetic material such as iron, and is substantially shaped like a disc including a bottom face **51**, a top face **52**, and a side face **53**. As shown in FIG. **3**, the cover **50** is disposed in the cylinder **12** so as to cover the guide pipe **30** and the coil unit **40** from the opposite side to the base **11** of the casing **10**, and when a front end **12***b* of the cylinder **12** of the casing **10** is swaged, as described later, the bottom face **51** contacts the yoke **47** integrated with the coil unit **40**, and the top face **52** contacts the front end **12***b* of the cylinder **12**.

The bottom face **51** of the cover **50** has a cylindrical first groove **51***a* opened from the bottom face **51** toward the top face **52**, and a cylindrical second groove **51***b* opened from the first groove **51***a* toward the top face **52**. The first groove **51***a* is formed to receive a sealing member **58**, and the second groove **51***b* is formed to receive an end of the small-diameter portion **32** on the side of the guide pipe **30**.

The top face **52** of the cover **50** is a face against which the front end **12***b* of the cylinder **12** contacts, and as shown in FIG. **12**, the cover **50** has a protrusion **52***a* that extends along the edge of a face **52** in the circumferential direction and protrudes from the face **52** by a predetermined height H. Thus, the front end **12***b* of the cylinder **12** can be swaged along the protrusion **52***a* in consideration that the front end **12***b* of the cylinder **12** is returned by spring back after swaging, the front end **12***b* of the cylinder **12** can be bent at a predetermined angle, 90 degrees in the present embodiment, with high accuracy.

The edge of the face **52** of the cover **50** further has, on the edge, grooves **52***b* axially dented further than a remaining area of the edge. In the present embodiment, as shown in FIG. **10**, the protrusion **52***a* formed on the edge of the face **52** is partially cut in the circumferential direction, and the cut portions of the protrusion **52***a* constitute the groove **52***b*. The four grooves **52***b* are formed on the cover **50** at regular intervals in the circumferential direction.

Thus, when the front end **12***b* of the cylinder **12** is swaged to the cover **50**, the front end **12***b* of the cylinder **12** can be dug into the grooves **52***b* of the cover **50**, preventing rotation of the cover **50** relatively easily without changing an assembling process.

As shown in FIG. **3**, a biasing force adjusting mechanism **60** for adjusting the biasing force of the plunger **20** is attached to the cover **50**. The biasing force adjusting mechanism **60** is configured of an adjusting screw **61** screwed into a screw portion **55** of the cover **50**, and a spring **62** that is mounted to the adjusting screw **61** and is attached to an attachment groove **22***b* formed at the rear end of the armature **22**.

The biasing force adjusting mechanism **60** rotates the adjusting screw **61** to adjust the biasing force of the spring **62**, thereby adjusting the biasing force of the plunger **20**. A seal nut **63** is screwed to the adjusting screw **61** to seal the adjusting screw **61** and the screw portion **55** of the cover **50**.

In the oil-immersed solenoid **1** thus formed, which includes the casing **10**, the plunger **20**, the guide pipe **30**, the coil unit **40**, and the cover **50**, the front end **12***b* of the cylinder **12** of the casing **10** is swaged to the cover **50**, and is bent along the top face **52** of the cover **50**.

In the oil-immersed solenoid **1**, as shown in FIG. **3**, in the state where the plunger **20**, the guide pipe **30**, the coil unit **40** integrated with the yoke **47**, and the cover **50** are assembled in the casing **10**, hydraulic oil is filled in the space **24** that houses the plunger **20**.

FIG. **13** is a sectional view schematically showing the guide pipe of the solenoid. In the guide pipe **30**, the inner face of the large-diameter portion **31** is sealed with the sealing member **18**, and the outer face of the small-diameter portion **32** is sealed with the sealing member **58**. When the oil-immersed solenoid **1** is filled with hydraulic oil, as shown in FIG. **13**, the both axial ends of the small-diameter portion **32** of the guide pipe **30** are equally pressed by the hydraulic oil with a pressing force P**1**.

Since the small-diameter portion **32** of the guide pipe **30** is subjected to the uniform pressing force of the hydraulic oil, movement of the guide pipe **30** is prevented, and as compared to the case where the guide pipe **30** is moved by the pressing force of the hydraulic oil, the reliability of the solenoid **1** can be improved.

In the oil-immersed solenoid **1** thus configured, current is supplied to the coil **41** through the terminal **43** to generate magnetic poles in the fixed magnetic pole **15** and a suction force corresponding to the current, and the armature **22** can be sucked by the suction force to move the plunger **20**.

Next, a method of assembling the oil-immersed solenoid **1** in the present embodiment will be described.

FIG. **14** is a view illustrating the method of assembling the solenoid, and shows cross sections of the casing **10**, the plunger **20**, the guide pipe **30**, the coil unit **40**, and the cover **50** that constitute the oil-immersed solenoid **1**. FIG. **14** does not show the biasing force adjusting mechanism **60**.

To assemble the oil-immersed solenoid **1**, first, the casing **10**, the plunger **20**, the guide pipe **30**, the coil unit **40** integrated with the yoke **47**, and the cover **50** are prepared, the sealing member **18** is attached to the annular groove **15***a* of the casing **10**, and the sealing member **58** is attached to the first groove **51***a* of the cover **50**. Then, as shown in FIG. **14**, the plunger **20**, the guide pipe **30**, the coil unit **40**, and the cover **50** are sequentially assembled in the cylinder **12** of the casing **10**.

Specifically, the plunger **20** is attached in the cylinder **12** of the casing **10** so as to insert the shaft **21** into the insertion hole **15***d* of the fixed magnetic pole **15**, the guide pipe **30** is fitted to the outer circumferences of the fixed magnetic pole **15** and the plunger **20**, the coil unit **40** is fitted to the outer circumference of the guide pipe **30**, and the cover **50** is attached to cover the guide pipe **30** and the coil unit **40**.

After that, in the state where the plunger **20**, the guide pipe **30**, the coil unit **40**, and the cover **50** are attached in the cylinder **12** of the casing **10**, the front end **12***b* of the cylinder **12** is swaged to the cover **50** by using a swaging die not shown, to hold the plunger **20**, the guide pipe **30**, the coil unit **40**, and the cover **50** in the casing **10**.

After the oil-immersed solenoid **1** is assembled in this manner, the biasing force adjusting mechanism **60** is attached. Then, the oil-immersed solenoid **1** is assembled to a valve device not shown, and hydraulic oil is supplied into the space **24**. It is noted that the oil-immersed solenoid **1** may not have the biasing force adjusting mechanism **60**.

As described above, in the oil-immersed solenoid **1** in the present embodiment, by integrating the fixed magnetic pole **15** with the casing **10** or attaching the fixed magnetic pole **15** to the casing **10**, attaching the plunger **20** in the cylinder **12** of the casing **10**, fitting the guide pipe **30** to the outer circumferences of the fixed magnetic pole **15** and the plunger **20**, fitting the coil unit **40** to the outer circumference of the guide pipe **30**, attaching the cover **50** so as to cover the guide pipe **30** and the coil unit **40**, and swaging the front end **12***b* of the cylinder **12** to the cover **50**, the plunger **20**, the guide pipe **30**, the coil unit **40**, and the cover **50** are held in the casing **10**. Since the solenoid **1** can be assembled so easily by sequentially inserting the plunger **20**, the guide pipe **30**, the coil unit **40**, and the cover **50** into the casing **10** and then, swaging the front end **12***b* of the cylinder **12** of the casing **10** as described above, the number of man-hours for assembling can be greatly decreased to reduce assembling costs.

Since the coil unit **40** has the recesses **46***b* in the end face **46***a* opposed to the base **11** of the casing **10**, and the projections **46***c* protruding from the bases of the recesses **46***b* further than the end face **46***a* in the recesses **46***b*, when the front end **12***b* of the cylinder **12** of the casing **10** is swaged to the cover **50**, the projections **46***c* of the coil unit **40** are squashed by the base **11** of the casing **10** such that the coil unit **40** is held by the casing **10**, thereby holding the coil unit **40** at the predetermined position to suppress rattle. Further, it is possible to prevent the coil unit **40** from oscillating when an external load acts on the solenoid **1**.

Although the grooves **52***b* axially dented from the edge of the top face **52** of the cover **50** are formed by cutting the protrusion **52***a* protruding from the top face **52** in the present embodiment, grooves axially dented from the top face **52** may be formed.

The present invention is not limited to the illustrated embodiment, and may be variously improved and changed in design so as not to deviate from the subject matter of the present invention.

INDUSTRIAL APPLICABILITY

As has been described, since the oil-immersed solenoid according to the present invention can be easily assembled to greatly decrease the number of man-hours for assembling and reduce assembling costs, the present invention can be preferably applied to the manufacturing of the oil-immersed solenoid or hydraulic equipment equipped with the oil-immersed solenoid.

DESCRIPTION OF REFERENCE SYMBOLS

1 OIL-IMMERSED SOLENOID
10 CASING
11 BASE
12 CYLINDER
13 FLANGE
15 FIXED MAGNETIC POLE
20 PLUNGER
21 SHAFT
22 ARMATURE
30 GUIDE PIPE
31 LARGE-DIAMETER PORTION
32 SMALL-DIAMETER PORTION
40 COIL UNIT
41 COIL
42 BOBBIN
46 MAIN BODY
47 YOKE
50 COVER

The invention claimed is:

1. An oil-immersed solenoid used for hydraulic control equipment, the oil-immersed solenoid comprising:

a casing including a base, a cylindrical cylinder extending from the base, and a flange extending from the base to an outside of the cylinder in an integral manner;

a fixed magnetic pole disposed to extend from the base into the cylinder;

a plunger including a shaft inserted into an insertion hole extending along an axis of the fixed magnetic pole, and an armature to which the shaft is fixed;

a cylindrical guide pipe fitted to an outer circumference of the fixed magnetic pole to cover the plunger;

a coil unit including a main body around which a coil is wound, and a connector provided on an outer circumferential face of the main body; and

a cover disposed in the cylinder to cover the guide pipe and the coil unit from an opposite side to the base of the casing, wherein

the fixed magnetic pole is integrated with the casing or the fixed magnetic pole is attached to the casing,

the cylinder of the casing has a notch cut in a circumferential direction to correspond to the connector of the coil unit, and

the plunger is attached in the cylinder of the casing so as to insert the shaft into the insertion hole of the fixed magnetic pole, the guide pipe is fitted to the outer circumference of the fixed magnetic pole to cover the plunger, the coil unit is inserted into a gap between the cylinder of the casing and the guide pipe, the cover is attached to cover the guide pipe and the coil unit, and in this state, a front end of the cylinder is swaged to the cover, to hold the plunger, the guide pipe, the coil unit, and the cover in the casing.

2. The oil-immersed solenoid according to claim **1**, wherein

a yoke is integrated with the coil unit, the yoke disposed adjacent to the main body on a side where the cover is arranged, and having an outer circumference of a larger outer diameter than the coil unit, and a step engaged with the outer circumference of the yoke is formed on an inner face of the cylinder of the casing.

3. The oil-immersed solenoid according to claim **1**, wherein

the coil unit has a recess in its opposed face to the base of the casing, and a projection protruding from the base of the recess further than the opposed face, in the recess.

4. The oil-immersed solenoid according to claim **1**, wherein

the cover has a protrusion protruding from an edge of a face of the cover, the face making contact with the front end of the cylinder when the front end of the cylinder is swaged.

5. The oil-immersed solenoid according to claim **1**, wherein

the cover has a groove on an edge of a face of the cover, the face making contact with the front end of the cylinder when the front end of the cylinder is swaged, the groove being axially dented further than a remaining area of the edge.

6. The oil-immersed solenoid according to claim **1**, wherein

the guide pipe includes a large-diameter portion fitted to the fixed magnetic pole and a small-diameter portion fitted to the armature of the plunger, and both axial ends of the small-diameter portion are pressed by hydraulic oil.

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